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Canadian Science Advisory Secretariat
Science Advisory Report 2007/023

2007 ASSESSMENT OF 4VWX HERRING

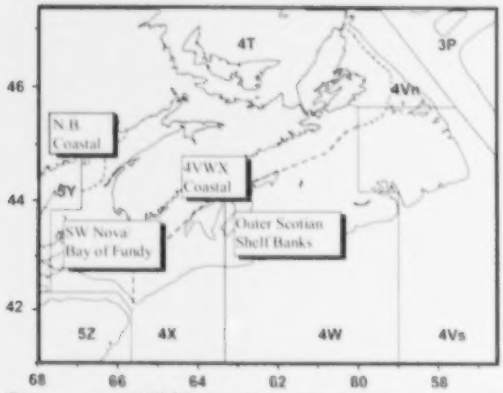

Figure 1. 4VWX herring management area and stock component locations.

Context

In support of scientific advice for the 2006/07 fishery, the 2007 assessment of the 4VWX herring stock complex was undertaken by the Regional Advisory Process. The meeting was held May 8-9, 2007 in St. Andrews, N.B. to review and evaluate biological and fishery information on 4VWX herring status as a basis for establishing quota for the 2006/2007 fisheries, as required in the Integrated Fisheries Management Plan. The terms of reference included an evaluation of the SW Nova Scotia / Bay of Fundy spawning component, and compilation and review of information regarding the offshore Scotian Shelf and the coastal Nova Scotia spawning components and an evaluation of the implications of ageing errors on the current VPA based assessment formulation. Participants included scientists, fishery managers, and representatives of the industry, provincial governments and other stakeholders.

The 2003-2006 Scotia-Fundy Herring Integrated Fisheries Management Plan (DFO 2003) set out principles, conditions, and management measures for the 4VWX herring fisheries. The main principle stated in the plan is "the conservation of the herring resource and the preservation of all of its spawning components". Three conservation objectives developed and reviewed in 1997 (Sinclair 1997) appear in the plan:

1) *To maintain the reproductive capacity of herring in each management unit through:*
   - *persistence of all spawning components in the management unit;*
   - *maintenance of biomass of each spawning component above a minimum threshold;*
   - *maintenance of a broad age composition for each spawning component; and*
   - *maintenance of a long spawning period for each spawning component.*
2) *To prevent growth overfishing:*
   - *continue to strive for fishing mortality at or below $F_{0.1}$*
3) *To maintain ecosystem integrity/ ecological relationships ("ecosystem balance"):*
   - *maintain spatial and temporal diversity of spawning*
   - *maintain herring biomass at moderate to high levels*

Progress against these objectives was evaluated at this meeting.

Since 1995, the herring stock assessment and related research has been increasingly dependant on a number of projects undertaken with the assistance of the fishing industry. These include industry sampling of biological characteristics of the catch, as well as acoustic surveys using industry vessels and tagging. A major review of the assessment framework including aspects of stock structure, sampling tagging results, acoustic surveys and design was completed in the fall and winter of 2006-07 (DFO 2007). Evaluation and review of assessment formulations and alternative models/approaches is yet to be completed.

June 2007

Canada

SUMMARY

SW Nova Scotia / Bay of Fundy

- Landings in 2005/06 were 49,150t against a TAC of 50,000t for the SW Nova Scotia / Bay of Fundy component. Landings have tracked the TAC in recent years with most of the quota being taken for each year since 2002.
- There is a lack of older/larger fish in the population. The length distribution in the catch for sizes greater than 30cm declined between 2000 and 2003 and remains at around 2%.
- In 2005/2006 industry made a concerted effort to re-direct to larger fish which resulted in a significant decrease in the proportion of fish less than 23 cm in the catch. This combined with the reduced TAC has allowed the proportion of adult fish from 23 to 30cm to increase.
- While the acoustic biomass signal is greater than in 2005 it is the second lowest in the time series. The overall biomass index estimated from acoustic surveys in 2006 represents an increase of 29% since 2005.
- Fishing mortality remains high and is considered to be well above $F_{0.1}$.
- Most of the conservation objectives specified for this fishery are not being met.
- This assessment indicates the low level of the resource noted in previous assessments. A harvest strategy that allows rapid population rebuilding is strongly recommended. Given the poor status and the uncertainties in estimating the exploitation rate for this stock any increase in catch may impede rebuilding.
- The potential benefits of the reduced quota in 2005 and 2006 will take time to be reflected in the biological characteristics of the population.

Offshore Scotian Shelf Banks

- Since 1996, a fishery has taken place on feeding aggregations on the offshore banks, primarily in May and June, with catches ranging from 1,000 to 20,000t. Total landings in 2006 were 9,800t.
- The summer bottom trawl research survey demonstrated considerable abundance of herring, widely spread over the Scotian Shelf but has declined substantially from the high of 2004.
- There is little new information to add and no reason to change the previous recommendation that the initial catch allocation for 2006 should not exceed the 12,000t used in the fishing plan.

Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia

- In 2006 there was an increase in surveyed acoustic biomass in the Halifax/Eastern Shore area while the Little Hope area saw a large decline. There was no survey effort in 2006 in the Glace Bay area.
- Management approaches and recent research efforts have improved knowledge in three areas (Little Hope/Port Mouton, Halifax/Eastern Shore and Glace Bay), but there has been no increase in knowledge in adjacent areas.
- There should be no large increases in effort in coastal spawning areas and no new fisheries developed when there is uncertainty regarding stock composition and degree of mixing.

SW New Brunswick Migrant Juvenile

- Landings of 12,900t were similar to 2005 but substantially lower than in 2004. There has been a trend of decreasing number of weirs in this fishery and decreasing landings over the past decade.

BACKGROUND

Species Biology

Atlantic herring is a pelagic species found on both sides of the North Atlantic. Herring spawn in discrete locations, to which they have a strong affinity. Herring mature and first spawn at three or four years of age (23 to 28 cm or 9 to 11 in), then begin an annual pattern of spawning, over-wintering, and summer feeding, which often involves considerable migration and mixing with members of other spawning groups. Most fishing takes place on dense summer feeding, over-wintering, and spawning aggregations.

The 4VWX management unit contains a number of spawning areas, separated to various degrees in space and time. Spawning areas in close proximity with similar spawning times, and which share a larval distribution area, are considered part of the same component. These undoubtedly have much closer affinity than spawning areas that are widely separated in space or time, and do not share a common larval distribution. Some spawning areas are large and offshore, whereas others are small and more localized, sometimes very near shore or in small embayments. The situation is complicated further as herring migrate long distances and mix outside of the spawning period both with members considered part of the same component and with members of other components. For the purposes of evaluation and management, the 4VWX herring fisheries are divided into four components:

1. SW Nova Scotia / Bay of Fundy spawning component
2. Offshore Scotian Shelf banks spawning component
3. Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia spawning component
4. SW New Brunswick migrant juveniles

Each component has several spawning areas, and there is mixing of fish among spawning components outside of the spawning period.

Fishery

Fisheries in the 4VWX area in recent years have been dominated by purse seine, weir and gillnet, with relatively minor landings by shutoff and trap.

Landings in 2005/06 were 49,150t against a TAC of 50,000t for the SW Nova Scotia / Bay of Fundy component (Table 1). Landings have tracked the TAC in recent years with most of the quota being taken for each year since 2002 (Figure 2). There were additional landings of 29,350t in the non-stock components for an area total of 78,500t. There was an increased proportion of catches from the German Bank/ SW Nova Scotia area in 2006.

Industry and management have explored means of managing the complexity within each component (such as distributing fishing effort among spawning areas according to their relative size) and of taking appropriate account of interaction among components (such as fishing restrictions on some areas of mixing).

Table 1. Reported landings (thousands of tonnes) and TAC for the 4VWX herring management unit by component from 2000 to 2006 with averages for prior decades.

Year	Average 1980-89	Average 1990-99	2000	2001	2002	2003	2004	2005	2006
4WX SW NS TAC*	106	112	100	78	78	93	83	50	50
4WX SW NS*	131	96	85	72	77	89	78	49	50
4VWX Coastal NS^	<1	4	4	6	10	9	7	7	7
Scotian S. Banks^	<0.1	13	2	12	7	1	4	5	10
SW NB^	24	24	17	20	12	9	21	13	13
Total Landings	155	137	108	110	106	108	110	74	79

* Quota year from Oct. 15 of the preceeding year to Oct 14 of the current year

^ Calendar year from Jan. 1 to Dec. 31

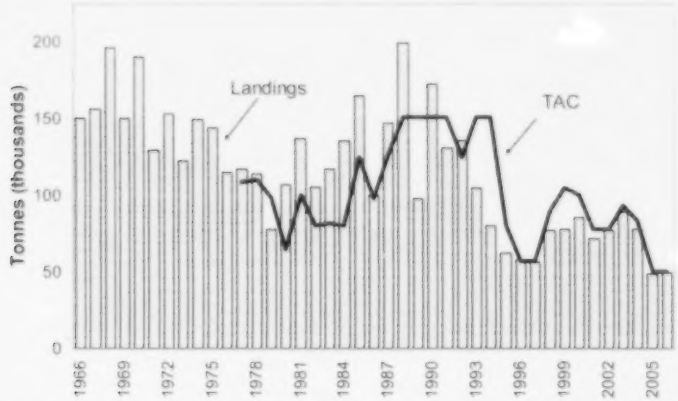

Figure 2. Landings (thousands of tones) and TAC for the SW Nova Scotia / Bay of Fundy spawning component.

ASSESSMENT FOR THE SOUTHWEST NOVA SCOTIA / BAY OF FUNDY SPAWNING COMPONENT

In 2006 the size distribution of the catch at length was composed of 35% <23cm (50% maturity at length), 63% from 23 to 30cm and 2% for sizes larger than 30cm (approx. 5-6 years old) (Figure 3). There is a lack of older/larger fish in the population. The length distribution in the catch for sizes greater than 30cm declined between 2000 and 2003 and remains at around 2% (Figure 4).

Prior to 2005, there was targeting of young fish and the high proportion of juveniles in the catch resulted in lost potential yield. In 2005/2006 industry made a concerted effort to re-direct to larger fish which resulted in a significant decrease in the proportion of fish less than 23 cm in the catch. This combined with the reduced TAC has allowed the proportion of adult fish from 23 to 30cm to increase (Figure 4). The total removals of fish by numbers were also reduced by close to 50% in 2005/2006 relative to 2004.

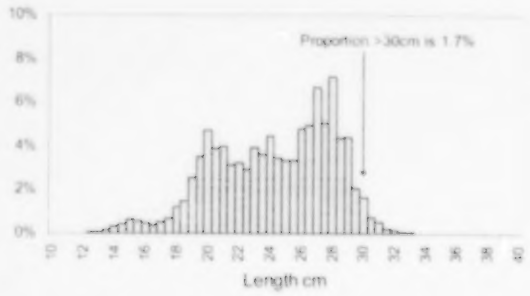

Figure 3. Catch at length (% number) for the 2006 overall SW Nova Scotia / Bay of Fundy herring spawning component.

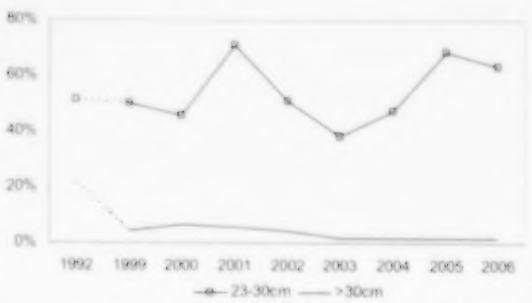

Figure 4. Proportions of size groups (% number) 23-30cm and >30cm herring in the catch from the SW Nova Scotia / Bay of Fundy spawning component.

Acoustic Surveys

Automated acoustic recording systems deployed on commercial fishing vessels were used to document the distribution and abundance of herring by industry vessel surveys. Scheduled surveys were conducted every 2 to 3 weeks on the main spawning components and an index of spawning stock biomass for each component was estimated by summing these results (Table 2).

A major source of uncertainty continues to be the assumption that the surveys are simply additive. If herring do not move on to and off of the spawning grounds in waves, the estimate of total SSB will be significantly biased upward due to double counting. As well, in recent years herring have been observed close to bottom, which may lead to an under-estimation of biomass from acoustic surveys.

In 2006, three surveys were conducted in Scots Bay, a reduction of one survey over the previous two years. Several external factors contributed to a decrease in fishing activity and survey effort including a reduced roe market, lack of access to the Digby wharf, re-introduction of Herring Fishing Area 22 (HFA-22) line closures and distance to market. Four surveys were again completed on German Bank. Individual survey area coverage was good and consistent with established protocols. Additional acoustic data from fishing nights in Scots Bay and German Bank were examined. The duration of the spawning fishery period in Scots Bay was the same as in 2005 but there was no observed spawning or catches of spawners in the spawning box in the middle of the period during early August. The duration of the spawning fishery on German Bank was similar to the previous years.

The documented amount of spawning fish on Trinity Ledge was higher than the past two years but survey coverage was again limited. There were no surveys and no reports of spawning herring on Lurcher Shoal, Seal Island and Browns Bank area grounds had fishing night estimates of presumed spawning fish.

Table 2. Acoustic survey biomass index for SW Nova Scotia / Bay of Fundy spawning component for 1999 to 2006 ('000's t). Blanks indicate that no survey was undertaken.

Location/Year	1999	2000	2001	2002	2003	2004	2005	2006	Average 1999-2006
Scots: lines	41	106	164	141	134	108	15	3	89
Scots:schools							2	26	14
Scots Bay total	41	106	164	141	134	108	17	29	92
German Bank	461	356	191	393	344	368	211	246	321
Trinity Ledge	4	1	15	8	15	7	5	9	8
Spec. - Spring			1		1		0		1
Spec. - Fall			88					0	44
Subtotal	506	463	458	542	493	482	233	283	432
German (outside box)								4	4
Seal Island			3	1	12			8	6
Browns Bank			46					6	26
Overall SSB	506	463	507	543	506	482	233	301	443
Overall SE %	19	14	10	9	17	15	28	16	16

* Spec. - Spectacle Buoy

While the acoustic biomass signal is greater than in 2005 it is the second lowest in the time series (Figure 5). The overall biomass index estimated from acoustic surveys in 2006 represents an increase of 29% since 2005.

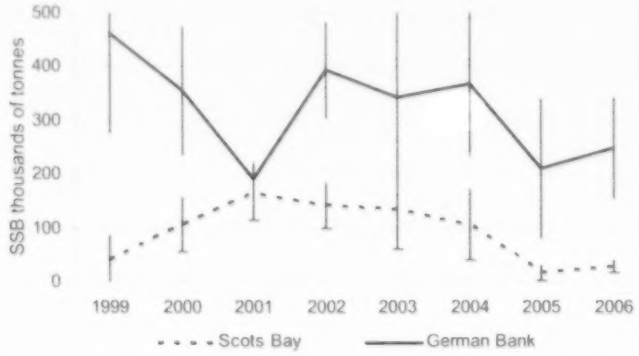

Figure 5. SSB index from acoustic surveys for the SW Nova Scotia / Bay of Fundy spawning component for Scots Bay and German Bank areas).

Between 1999 to 2003, acoustic survey results were used as minimum estimates of absolute SSB abundance and the population was considered to be approximately 500,000t. An SSB of that size would have been expected to result in substantial growth of the population, improved age composition and low fishing mortality, given reasonable recruitment and the landings over that period. The expected growth in the population has not been observed in the surveys and an increase in proportion of larger/older fish has not been observed in either the surveys or the fisheries. The small proportion of larger/older fish in the population indicates that the total mortality on this stock is high.

Stock Trends and Current Status

A population model (Virtual Population Analysis, VPA) was conducted on this stock component in 2005. Estimates of relative abundance from the acoustic surveys were used to calibrate the

analysis. While the trends in modeled abundance followed those in the survey, there was an inconsistency in the absolute estimate of biomass determined by the VPA and the absolute estimate provided by the acoustic survey. This inconsistency has not been resolved but could be due to issues with the survey (e.g. double counting, target strength) and/or the VPA (e.g. ageing, unaccounted mortality).

In April of 2006, ageing inconsistencies were identified that may have an impact on the age based assessment results (DFO 2006) (Figure 6). The terms of reference for this meeting requested "An evaluation of the southwest Nova Scotia / Bay of Fundy spawning component, including an evaluation of the implications of the aging errors uncovered in 2006 on the current VPA-based assessment formulation." To test the sensitivity of the VPA to changes in the age input, several growth models using age-length keys from selected years were applied to the catch at age and the indices of abundance from 1999 to 2006 and input into the 2005 VPA formulation. The estimated fishing mortalities for 1995-2006 from these simulations (Figure 7) were variable and consistent with the previous investigation (Figure 6), and no scenario produced fishing mortalities at or below $F_{0.1}$ (F=0.23).

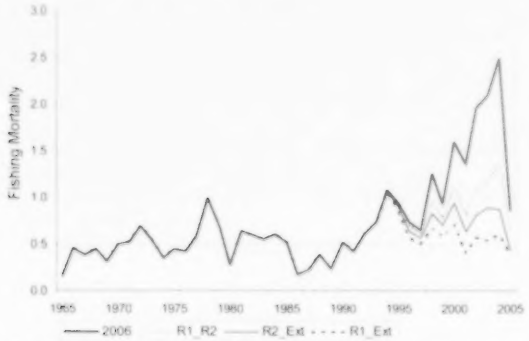

Figure 6. Fishing mortality (ages 5-8 weighted by population numbers) from a series of VPA's calibrated with the German Bank acoustic index for the Expert Opinion (DFO 2006).

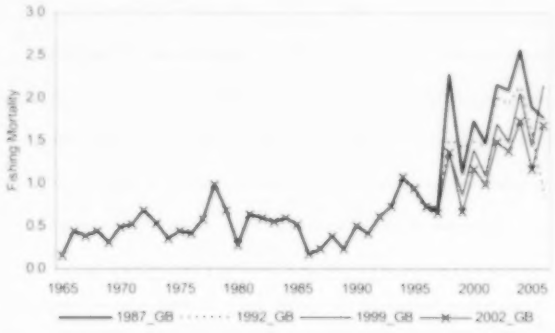

Figure 7. Fishing mortality (ages 5-8 weighted by population numbers) from a series of VPA's calibrated with the German Bank acoustic index for this assessment.

Fishing mortality remains high and is considered to be well above $F_{0.1}$. This is supported by the simulations and the contracted size range observed in the catch and survey (Figure 3). However, the recent increase in abundance of herring in the 23-30cm size range is a positive signal for potential future population growth (Figure 4). In addition some spawning was observed on Seal Island in 2006 and all spawning areas experienced a slight increase in survey biomass since 2005. Further, the start and duration of spawning on German Bank appeared normal. On balance however, the stock is still low relative to historical levels.

There is no independent index of recruitment and a large fraction of the catch is dependent on recruiting year classes.

Sources of Uncertainty

- There is uncertainty related to residency time on the spawning grounds.
- There is an inconsistency between the absolute abundance calculated from the acoustic surveys and the VPA estimates of biomass.
- There is uncertainty with age determinations of 3+ herring for this stock which is under review.

- There is uncertainty in VPA estimates of F using age based inputs constructed from another year's ageing data.
- In recent years, herring have been observed close to bottom, which may lead to an under-estimation of biomass from acoustic surveys.
- There is no independent index of recruitment and a large fraction of the catch is dependent on recruiting year classes.

CONCLUSIONS AND ADVICE

The objectives for this stock from the management plan and the current observations are summarized below. Most of the conservation objectives specified for this fishery are not being met.

Objective	2006: Observations
Persistence of all spawning components	Spawning not observed on Lurcher. Biomass increases in Scots and Trinity still low. Some spawning near Seal Island.
Maintain biomass of each component	All spawning areas had slightly increased biomass estimates from 2005 but are still at historically low levels. Substantial decline from 2004. Scots, Trinity, Lurcher and Seal are at very low biomass.
Maintain broad age composition	Proportion of larger (30 cm+) sizes has contracted and is very low. Age composition is assumed to be truncated with an absence of larger fish in the population. Recent increase in abundance of herring in the 23-30cm size range is a positive signal for potential future population growth.
Maintain long spawning period	Start and duration of spawning in 2006 for German Bank appeared normal but Scots Bay displayed a midseason gap.
Fishing mortality at or below F0.1	Fishing mortality is likely high and well above F0.1.
Maintain spatial and temporal diversity of spawning	Insufficient spawning in some areas.
Maintain biomass at moderate to high levels	SSB remains near the lowest recorded level since 1999 from the acoustic surveys.

This assessment indicates the low level of the resource noted in previous assessments. A harvest strategy that allows rapid population rebuilding is strongly recommended. Given the poor status and the uncertainties in estimating the exploitation rate for this stock any increase in catch may impede rebuilding.

OTHER CONSIDERATIONS

The potential benefits of the reduced quota in 2005 and 2006 will take time to be reflected in the biological characteristics of the population.

The acoustic index provides fisheries independent information on the spawning stock biomass but does not provide data on younger age classes. The size of herring year-classes is highly variable and there is no index of recruitment. Anecdotal information and significant catches of small fish in the New Brunswick weirs of the 2005 year class may indicate the presence of a strong year-class. However, large numbers of young fish in the 1980 NB weir catch did not translate into a strong year class.

ASSESSMENT, CONCLUSIONS AND ADVICE FOR OTHER COMPONENTS

Offshore Scotian Shelf

Since 1996, a fishery has taken place on feeding aggregations on the offshore banks, primarily in May and June, with catches ranging from 1,000 to 20,000t (Figure 8). Total landings in 2006 were 9,800t with most landings by purse seine and midwater trawl in May and June, in the vicinity of the Patch, Emerald and Western banks. There was also effort near the shelf edge and east of Sable Island both in January and the late fall by midwater trawlers.

In 2006, the size composition of the catch was mostly adult fish >23cm (50% maturity at length) with a substantial proportion (23%) larger than 30cm (Figure 9).

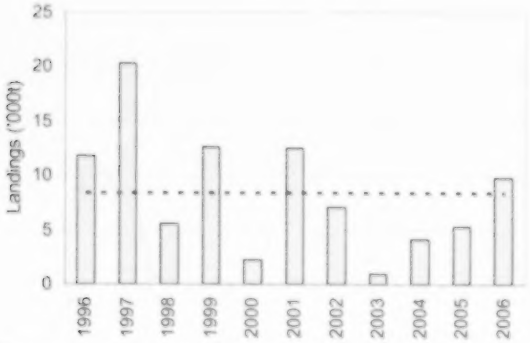

Figure 8. Offshore Scotian Shelf herring landings since 1996 with overall average for the period.

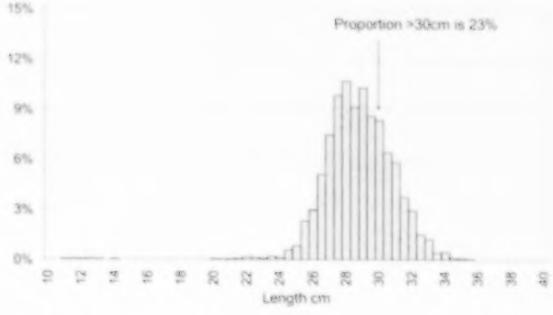

Figure 9. Catch at length (% numbers) for the 2006 Offshore Banks herring component.

There have been no industry surveys of the offshore Scotian Shelf area since 2001. The summer bottom trawl research survey demonstrated considerable abundance of herring, widely spread over the Scotian Shelf but has declined substantially from the high of 2004 (Figure 10). Information from biological sampling indicated the presence of at least some autumn spawning near Western Bank and Sable Island.

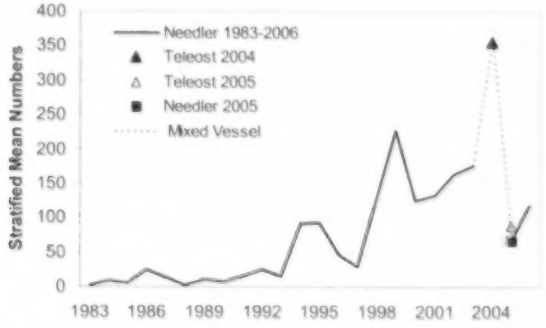

Figure 10. Number of herring caught per standard tow in the DFO summer bottom trawl survey of the offshore Scotian Shelf Banks, 1970 to 2006 (strata 55-78; from Sable Island to Baccaro Line). Survey results for Teleost and Alfred Needler in 2004-2005 are identified individually.

There is little new information to add and no reason to change the previous recommendation that the initial catch allocation for 2006 should not exceed the 12,000t used in the fishing plan. The industry should be encouraged to explore and undertake structured surveys of the offshore area.

Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia

There is no quota for the coastal Nova Scotia spawning component and, apart from four areas; the size and historical performance of various spawning groups are poorly documented (Table 3). In addition to the traditional bait and personal-use fisheries, directed roe fisheries have occurred on several spawning grounds in recent years.

Table 3. Recorded landings (thousands of tonnes) of herring from major gillnet fisheries on the Coastal Nova Scotia spawning component.

Landings	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Little Hope		0.5	1.2	2.9	2.0	2.9	4.0	4.5	1.3	2.2	3.1
Eastern Shore	1.3	1.5	1.1	1.6	1.4	1.9	3.3	2.7	4.2	3.5	3.4
Glace Bay		0.2	1.7	1.0	0.8	1.2	3.1	1.9	1.5	0.6	0.1
Bras d'Or	0.2	0.2	0.1	0.0	0.1						
Total	1.5	2.3	4.1	5.6	4.3	6.0	10.4	9.1	7.0	6.3	6.6

As the inshore roe fisheries off Glace Bay, East of Halifax and Little Hope have developed, participants have contributed to sampling and surveying of the fisheries.

The recorded landings of 6,600t in 2006 in the four major gillnet fisheries along the coast of Nova Scotia were higher for Little Hope/Port Mouton area, about the same for the Eastern Shore area, minimal for Glace Bay and the Bras d'Or Lakes fishery remained closed.

In 2006 there was an increase in surveyed acoustic biomass in the Halifax/Eastern Shore area, while the Little Hope area saw a large decline (Table 4, Figure 11, 12). A survey with an acoustic recorder had been completed for the first time in the Glace Bay area 2005 but there was no survey effort in 2006.

Table 4. Estimated acoustic spawning survey biomass (thousands of tonnes) of herring from major gillnet fisheries in the Coastal Nova Scotia spawning component. Blanks represent no survey completed. All data was calculated without the use of the integration calibration factor.

Acoustic Survey SSB (000's t)									
Acoustic Survey SSB	1998	1999	2000	2001	2002	2003	2004	2005	2006
Little Hope	14.1	15.8	5.2	21.3	56.0	62.5	15.6	39.5	21.7
Eastern Shore	8.3	20.2	10.9	16.7	41.5	67.6	18.2	28.1	51.1
Glace Bay		2.0		21.2	7.7	31.5	0.0	2.2	
Bras d'Or		0.5	0.1						

As indicated for the SW Nova Scotia / Bay of Fundy component, summing of multiple surveys may result in overestimates of SSB due to double counting. However, the majority of surveys of the Coastal Nova Scotia spawning component were undertaken on spatially separated aggregations of fish.

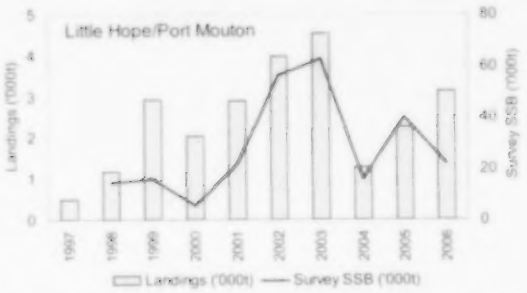

Figure 11. Landings and acoustic survey SSB ('000t) for the Little Hope/Port Mouton gillnet fishery for 1997-2006.

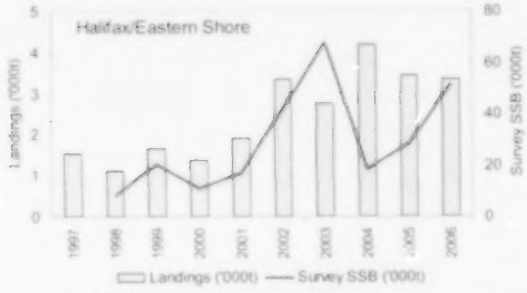

Figure 12. Landings and acoustic survey SSB ('000t) for the Halifax/Eastern Shore gillnet fishery for 1997-2006.

Management approaches and recent research efforts have improved knowledge in three areas (Little Hope/Port Mouton, Halifax/Eastern Shore and Glace Bay), but there has been no increase in knowledge in adjacent areas. Individual spawning groups within this component are considered vulnerable to fishing because of their relatively small size and proximity to shore. As in the past five years, it is recommended that no coastal spawning areas experience a large effort increase until enough information is available to evaluate the state of that spawning group. There should be no large increases in effort in coastal spawning areas and no new fisheries developed when there is uncertainty regarding stock composition and degree of mixing.

It has been noted since 1997 that the status of herring in the Bras d'Or Lakes is cause for concern. It is therefore appropriate to reiterate that no fishing should take place on this spawning component.

SW New Brunswick Migrant Juveniles

Approximately 12,900t of herring, considered to be a mixture of fish originating primarily from NAFO Subarea 5, were landed in the traditional New Brunswick weir and shutoff fishery in 2006. Landings were similar to 2005 but substantially lower than in 2004. The size of herring caught from this fishery was abnormally small throughout the season and impeded markets (Figure 13).

In 2006, the size composition of the catch was primarily juvenile fish (<23cm) with a substantial proportion (47%) less than 15cm, which is considered to be mostly age 1 (Figure 13). While large proportions of age 1 fish have been found in the SW New Brunswick catches in the past, for example 70% in 1980, these have not translated into strong recruitment in subsequent years (Figure 14). There has been a trend of decreasing number of weirs in this fishery and decreasing landings over the past decade.

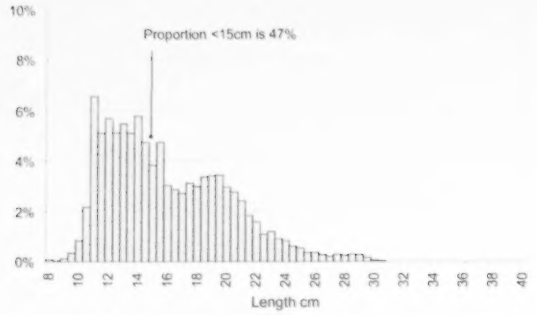

Figure 13. Catch at length (% numbers) for the 2006 SW New Brunswick migrant juvenile herring component.

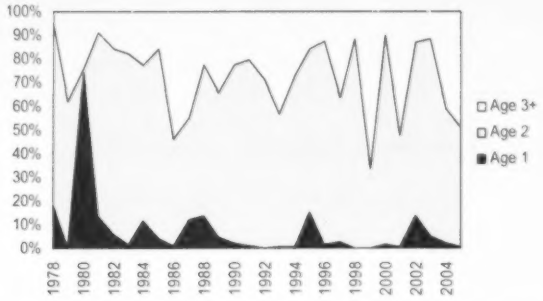

Figure 14. Catch at age (% numbers) for the 1978-2005 SW New Brunswick migrant juvenile herring component.

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